Ultra-Wideband UHF Microstrip Array for GeoSAR Application

Robert F. Thomas and John Huang

Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Drive
Pasadena, CA 91109

Introduction: GeoSAR is a program sponsored by DARPA (Defense Advanced Research Projects Agency) and NASA (National Aeronautics and Space Administration) to develop an airborne, radar-based, commercial terrain mapping system for identification of geologic, seismic, and environmental information, It has two (dual-band at X and UHF) state-of-the-art interferometric synthetic aperture radar (SAR) ground mapping systems. The UHF interferometric system is utilized to penetrate the vegetation canopy and obtain true ground surface height information, while the X-band system will provide capability of mapping the top foliage surface. This paper presents the UHF antenna system where the required center frequency is 350 MHz with a 160 MHz of bandwidth (46% from 270 MHz to 430 MHz). The antenna is required to have dual-linear polarization with a peak gain of 10 dB at the center frequency and a minimum gain of 8 dB toward two ends of the of the frequency band. One of the most challenging tasks, in addition to achieving the 46% bandwidth, is to develop an antenna with small enough size to fit in the wing-tip pod of a Gulfstream II aircraft.

Antenna Description: The selected antenna configuration is a 4-element array of cavity-backed annular microstrip patches as shown in Figures 1 and 2. Relatively thick air substrate (thickness = 10 cm) is used to achieve the wide-band performance. Each cavity has a square dimension of 43.2 cm and each annular patch, as shown in Figure 1, has an outer dimension of 35.6 cm and an inner dimension of 7 cm. The 4-element array has the overall dimensions of 173 cm by 43.2 cm.

Each patch is fed by four identical probes arranged 0°, 180°, 0°, 180° in both angular location and phase to provide dual-linear polarization and to cancel higher-order modes for wide band application [1,2]. All four identical probes, shown in Figure 3, are uniquely designed and tuned to provide enough capacitance to cancel the undesirable inductance that generally exists at the input feed of a relatively thick microstrip substrate ‘3]. Each feed probe, with its components shown in Figure 4, basically consists of two different-size metallic cylinders. The smaller one, having a cone-shaped end, fits into the larger one and is separated with a small gap (0.3 cm) from the larger one by a Teflon cylinder. The top of the smaller cylinder is separated from the radiating patch also with a small gap (0.2 cm) by a thin Teflon disk, It is these small gaps and the cone-shaped end that provided the needed capacitance to cancel the inductance over the wide bandwidth. The shape of this probe is achieved basically through empirical tuning. To summarize, three major techniques were developed to achieve the wide band performance. These are : 1) by using a thick air substrate, 2) by employing four probes with opposite feeds and opposite phases, and 3) by developing a special feed probe.

Wide bandwidth can certainly be achieved by using the aperture coupling technique [4,5] without using any special feed probe. However, aperture coupling requires an additional layer of solid dielectric substrate at the bottom of the ground plane. At this relatively low UHF frequency, an additional solid dielectric layer would introduce significant amount of mass which is not desirable for a wing-tip mounted structure.

Measurement Results: The input VSWRS for both the vertical-polarization and horizontal polarization ports measured at each of the four feed probes are given in Figure 5. It demonstrated that the antenna has excellent impedance match over the required bandwidth of 270 MHz to 430 MHz. Both the azimuth and elevation patterns of the array's horizontal-polarization port measured at the center frequency of 350 MHz are shown in Figure 6. The same set of patterns for the vertical-polarization port are given in Figure 7 where higher backlobe level is observed. This relatively high backlobe is expected due to the higher diffraction amount by the vertically polarized fields from the narrow aperture in the vertical-plane cut. Patterns measured at the band edges are very similar to those shown in Figures 6 and 7 and will be presented in the symposium. The measured antenna gain of the 4-element array at the frequencies of 270 MHz, 350 MHz, and 430 MHz are 8 dB, 10 dB, and 11 dB, respectively. The 10 dB gain at the center frequency shows an aperture efficiency of 80%. This relatively good efficiency is expected since the insertion losses of the power divider, cables, and hybrids are very small at this low UHF frequency. The isolation measured between the two orthogonal ports is 37 dB across the band, which is achieved through the 0°, 180°, 0°, 180° feed probe arrangement. The fields from the two opposing probes travel to the orthogonal probe and are canceled because they are 180° out of phase, and ,hence, the high coupling in this relatively thick substrate is avoided.

Acknowledgment: The research described in this paper was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

References:

1. T. Chiba, Y. Suzuki, and N. Miyano, "Suppression of Higher Order Modes and Cross Polarized Components for Microstrip Antennas," IEEE AP-S Symposium, May 1982, pp. 285-288.
2. J. Huang, "Low Cross-Pol Linearly Polarized Microstrip Array," IEEE AP-S Symposium, Dellas, Texas, May 1990, pp. 1750-1753.
3. J. Huang, "Stripline Feed for a Microstrip Array of Patch Elements with Teardrop Shaped Probes," U.S. Patent No. 4973972, Nov. 1990.
4 D. Pozar, "A Microstrip Antenna Aperture Coupled to a Microstripline", Electronics Letters, vol. 21, Jan. 1985, pp. 49-50.
5. S.D. Targonski and R. B. Waterhouse, "An Aperture Coupled Stacked Patch Antenna with 50% Bandwidth", IEEE AP-S Symposium, Baltimore, Maryland, July 1996, pp. 18-21.

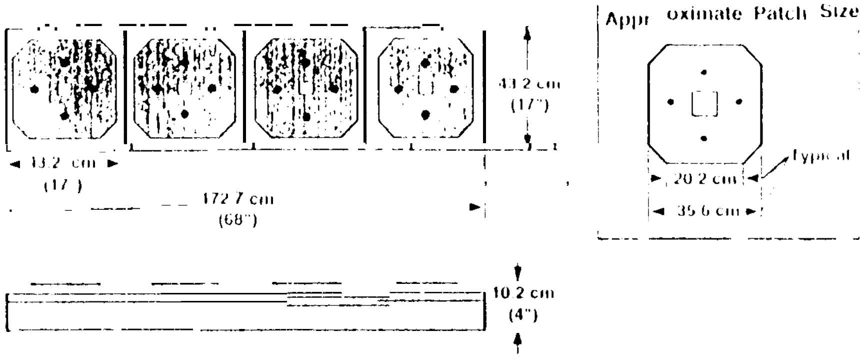

Figure 1. Sketch of the 4-element annular patch array with dual-linear polarization

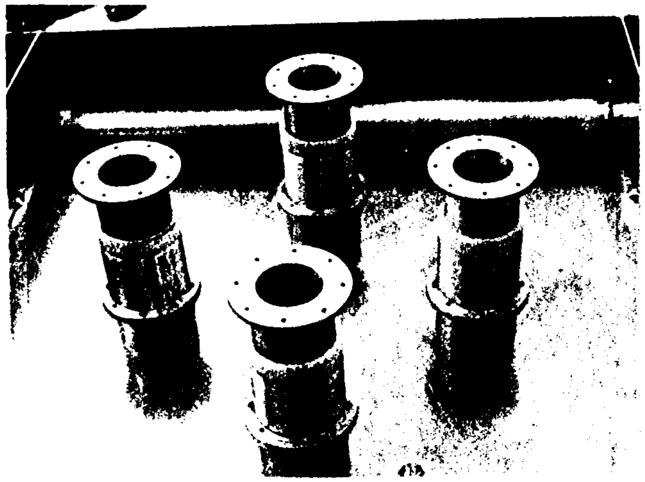

Figure 3. Photograph of the four feed probes inside the element cavity

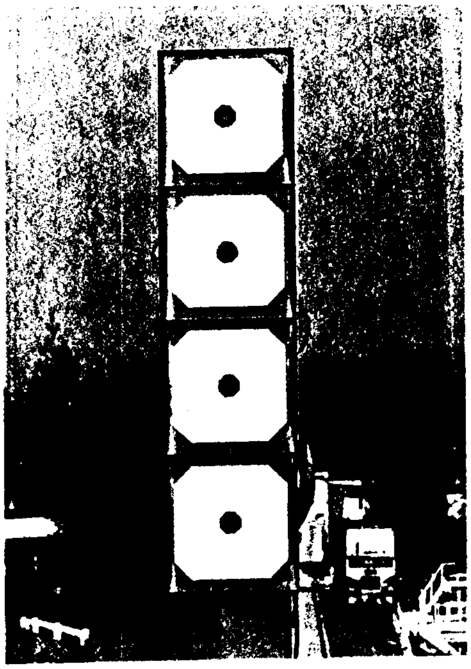

Figure 2. Photograph of the 4-element annular patch array

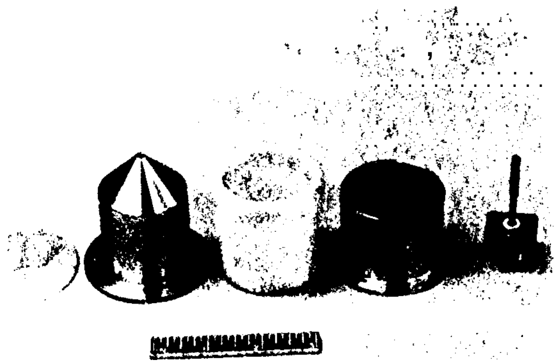

Figure 4. Components of each feed probe

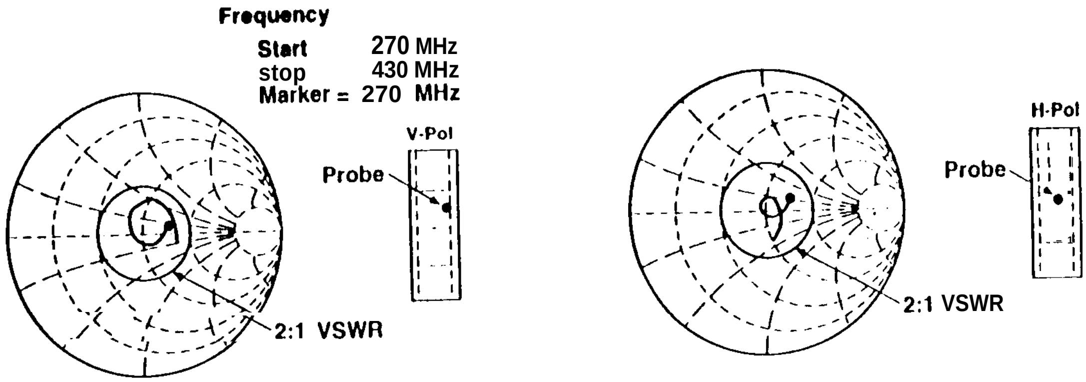

Figure 5. Measured input **impedance match** for both the **V-pol and H-pol** ports.

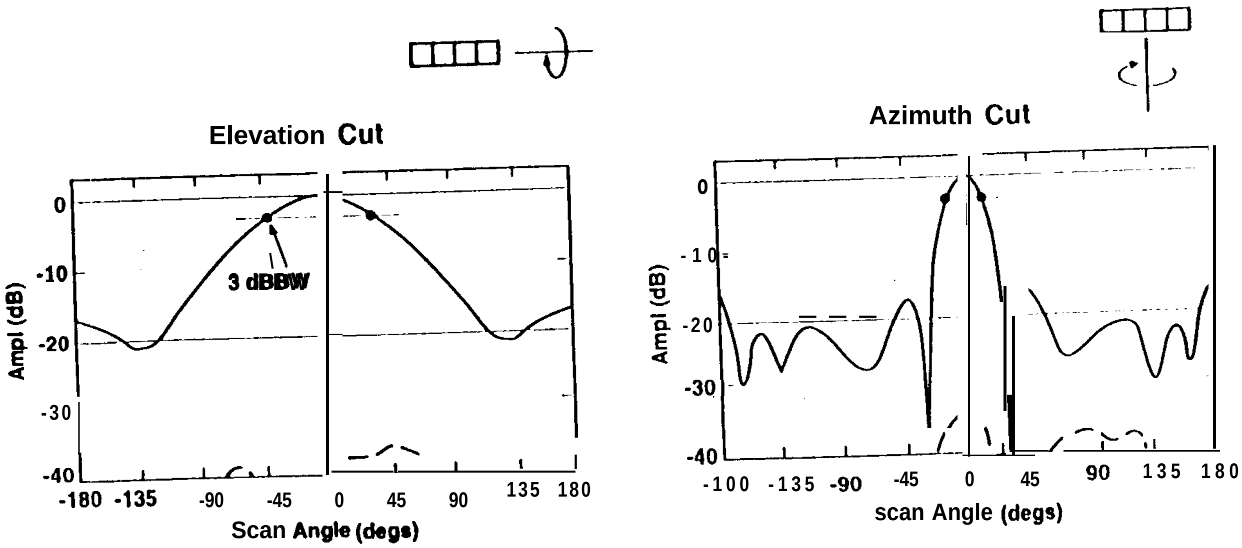

Figure 6. Measured elevation and azimuth patterns for the **H-pol** port at 350 MHz.

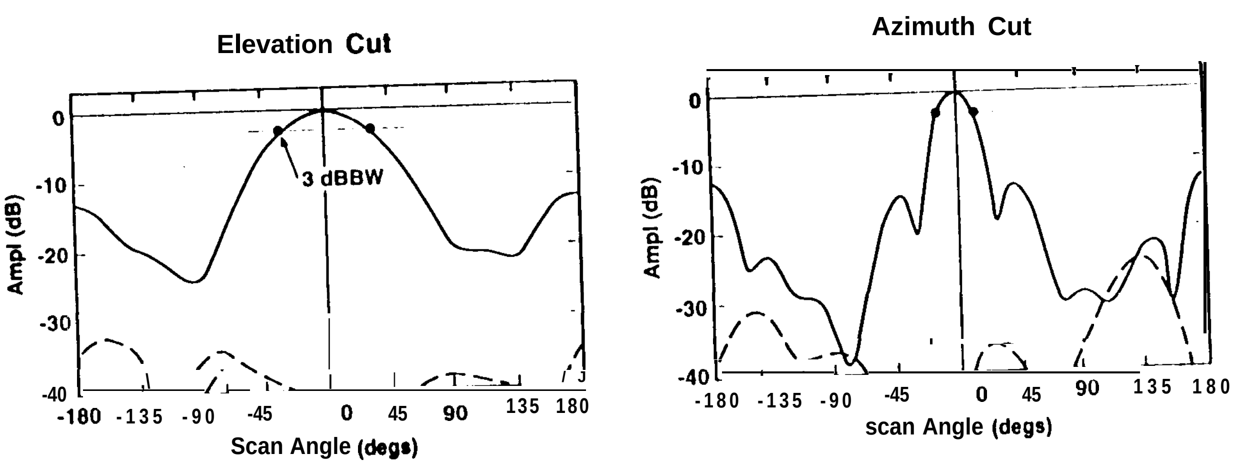

Figure 7. Measured elevation and azimuth patterns for the **V-pol** port at 350 MHz.